

Lunar Surface Operations: Part II

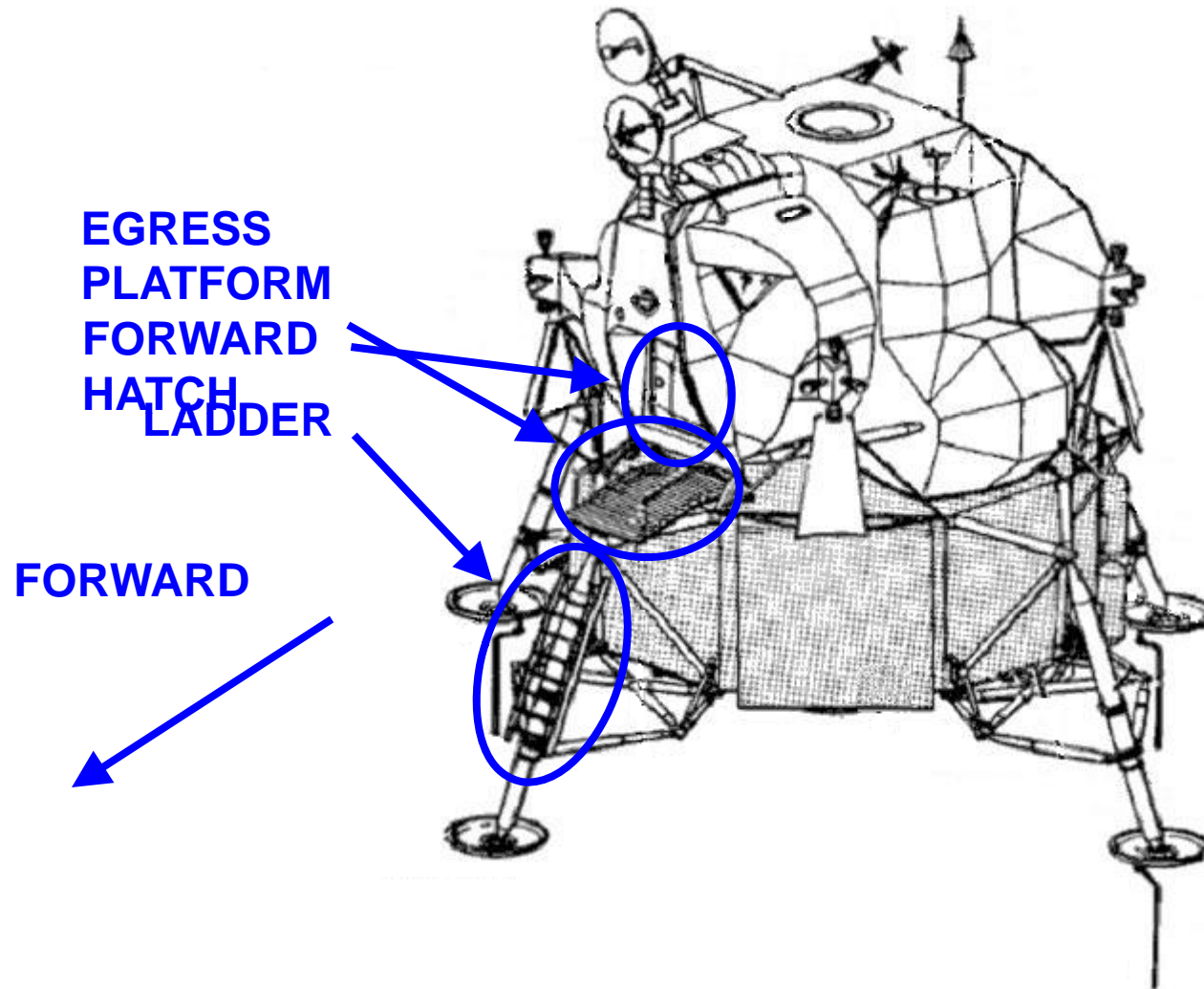
Surface Duration

Objectives

Part 1	Part 2	Part 3
Post-Touchdown Lunar Surface & Systems Checkout	Surface Duration	Pre-Launch Lunar Surface & CSM Plane Change

- ☐ Summarize Lunar Module Basics emphasizing module layout and storage.
- ☐ Identify the primary activities occurring during each of the lunar surface timelines.
- ☐ List the EVA Prep tasks
- ☐ Identify the EVA Objectives
- ☐ Identify the activities associated with Post EVA
- ☐ Describe the lessons learned during both EVA and Non EVA activities

LM Basics



Ascent Stage

Apollo 17 Cabin Prep for EVA-1

DATE 11/6/72

115:15 EQUIPMENT PREP EVA 1 (25 Min)

Empty UCTA's (WMS Valve), Install Cap

HTR CONT: URINE LINE - OFF

CP (11) HTR: URINE LINE - Open

Check PGA Zippers, Verify Lock - Lock

Stow PGA Air Eon Plugs In Purse

Empty PGA Pockets Into Purse

PGA Relief Valve Cap In Pkt

→ CDR Move To Aft Cabin Area

→ Unstow CDR Boots, Purge Valve And
Donning Lanyard To Purse

→ CDR Don Boots

→ Unstow CDR OPS

→ Remove Pallet, Stow In Jett Bag
Perform OPS Check, Restow OPS

→ LMP Move To Aft Cabin Area

→ Unstow LMP Boots, Purge Valve To Purse

→ Stow IV Gloves In Bot Boot Comp

→ LMP Don Boots

→ Unstow LMP OPS

Remove Pallet, Stow In Jett Bag

→ Perform OPS Check

→ Stow LMP OPS On Eng Cover

Install ISS

→ Apply Antifog (LEVA Bags), Wipe Dry
With Tissue (LHSSC)

→ Stow EMU Maintenance Kits In Purse

→ Stow LEVA's, Helmets & EV Gloves

(Attach Watch & Mirror) On ISS

→ Stow LEVA Bags Under SRC Compt

→ Stow BFA

→ Move CDR's OPS To Front Of Eng Cover

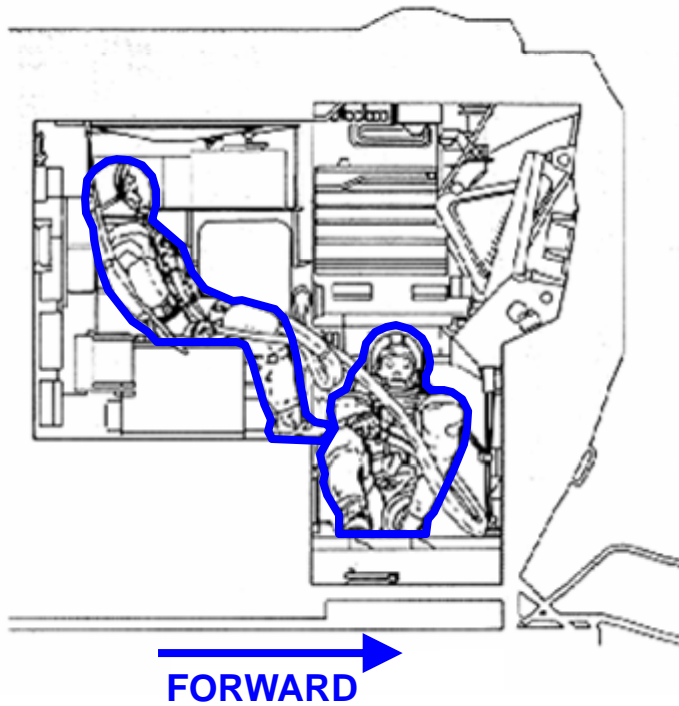
→ Stow ETB On Aft Eng Cover

→ Tie Jett Bag, Stow On Aft Engine Cover

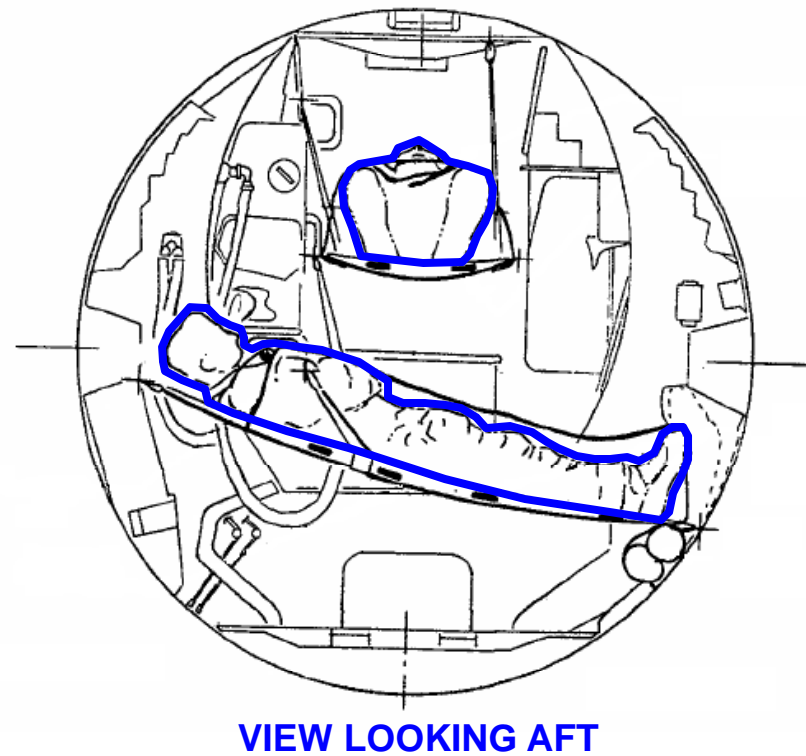
Fwd Hatch Handle - UNLOCK

Forward Crew Stations
AFT CABIN AREA

Ascent Stage

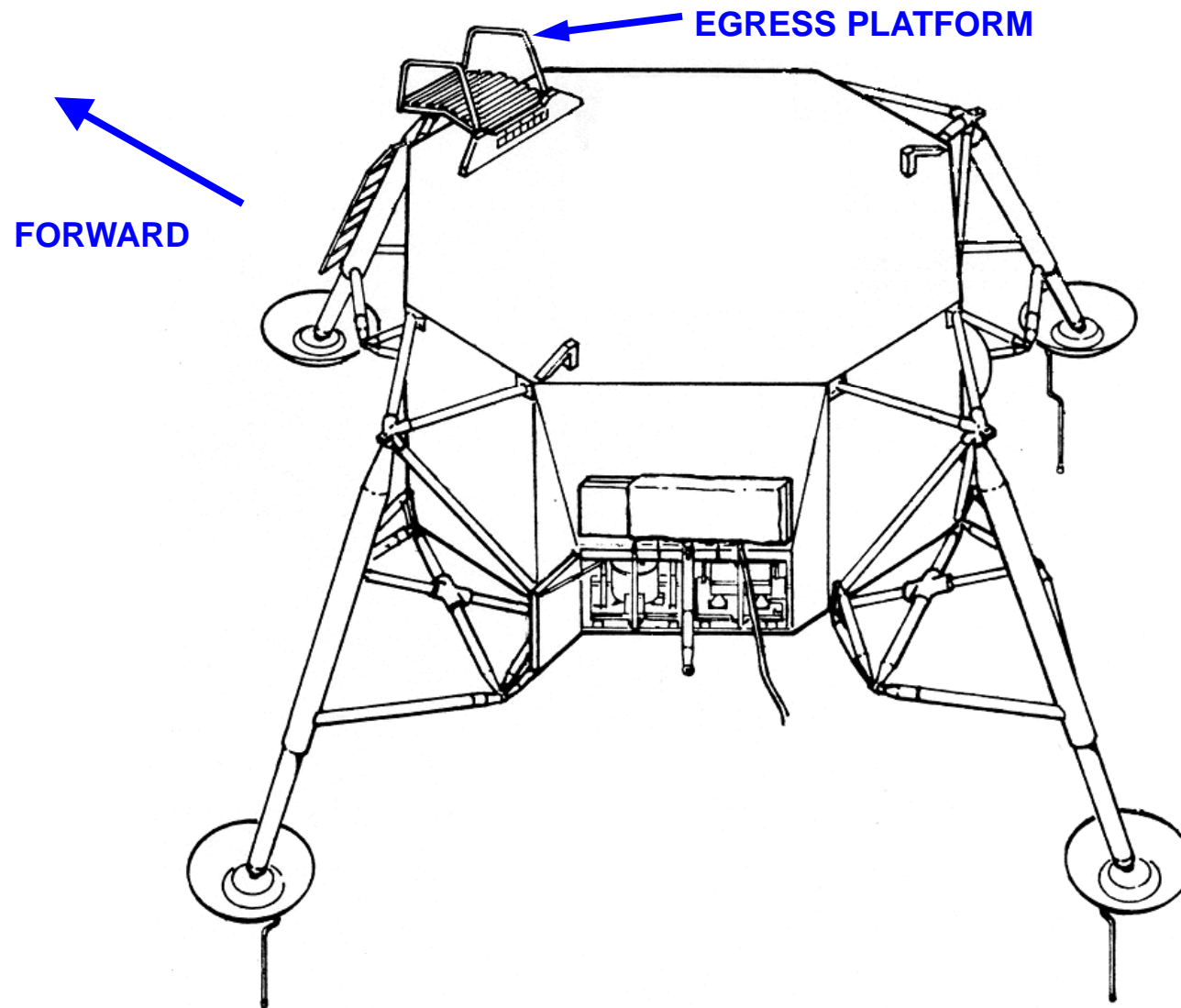


Apollo 11

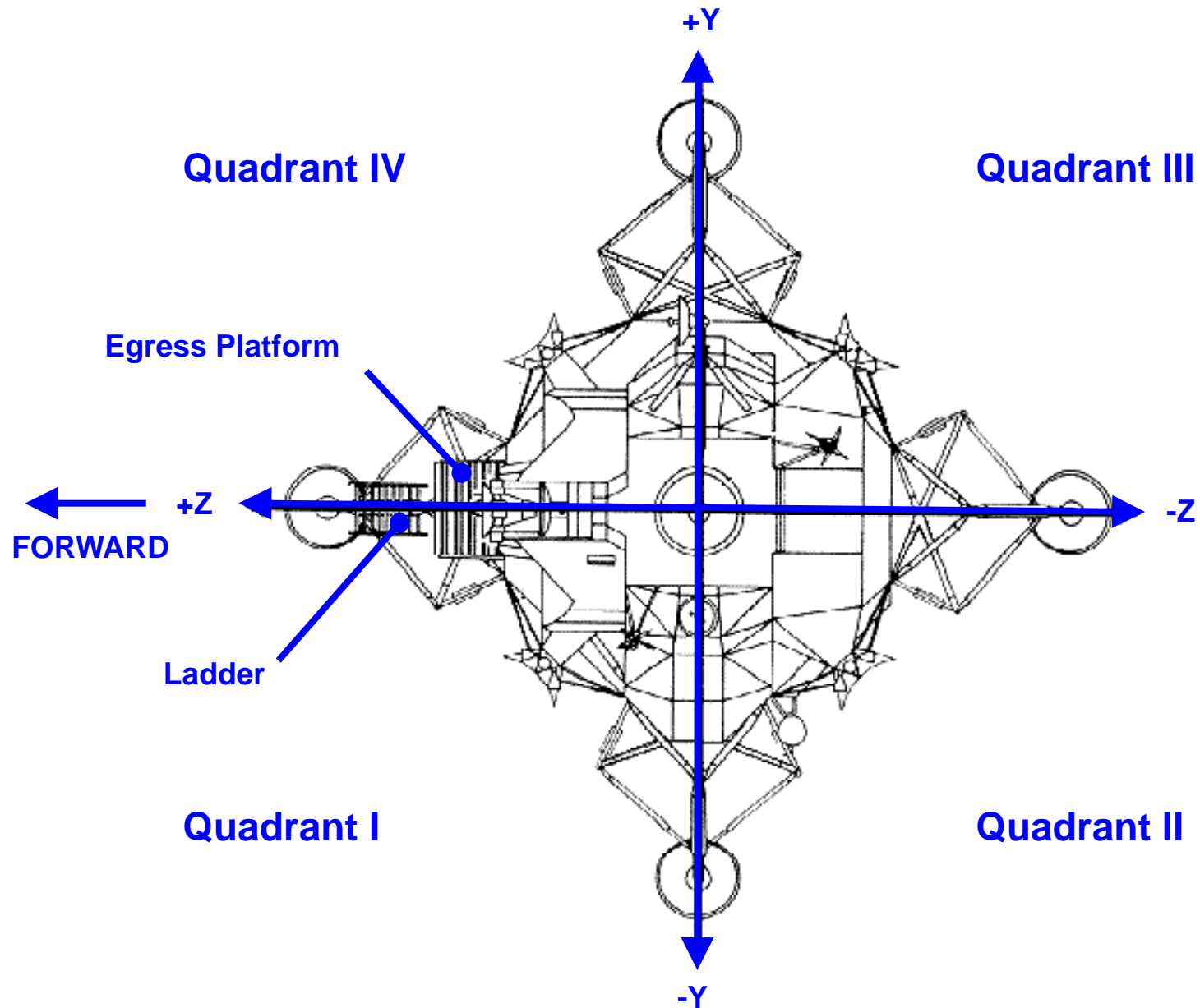


Apollo 12-17

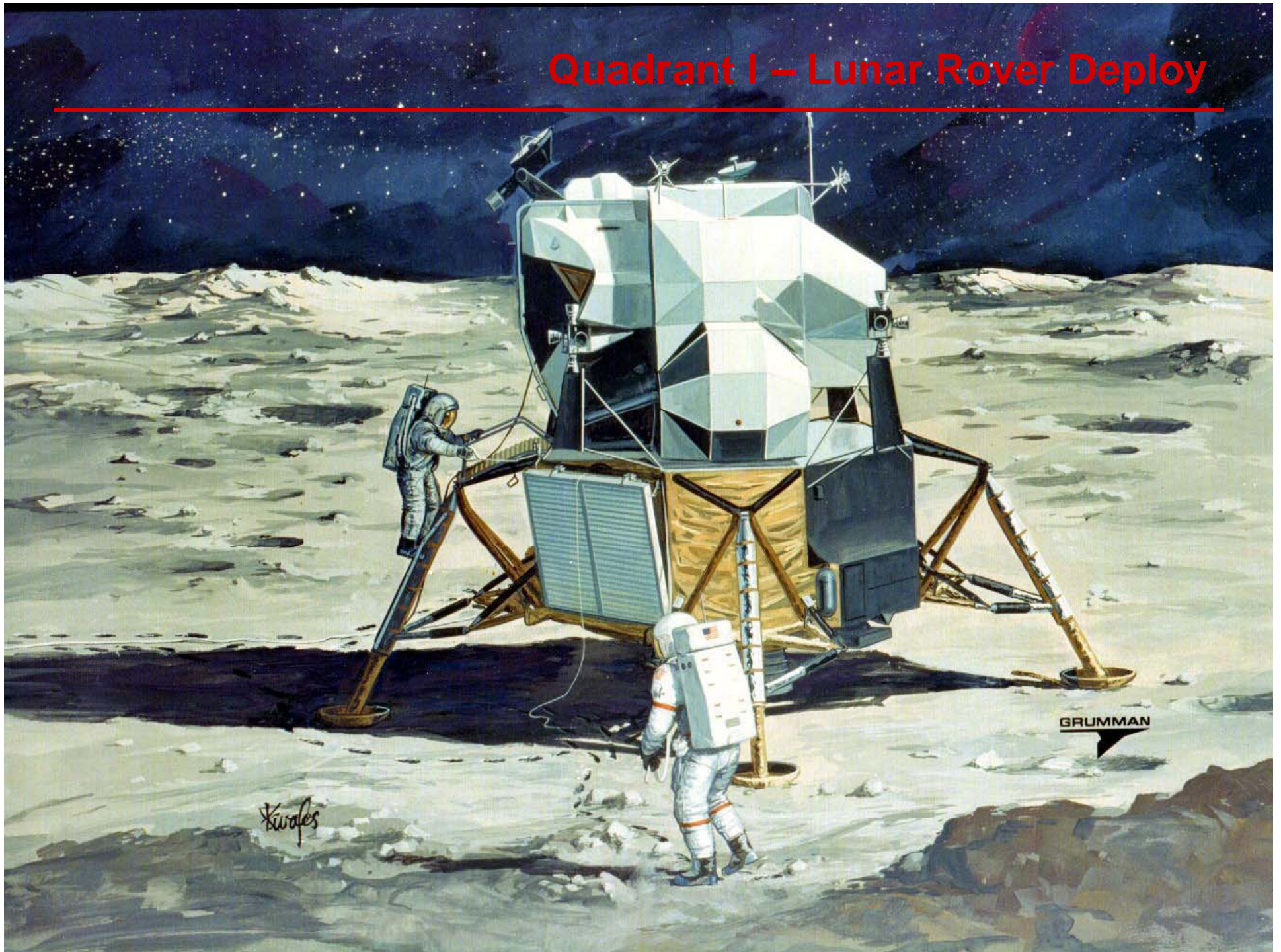
Descent Stage



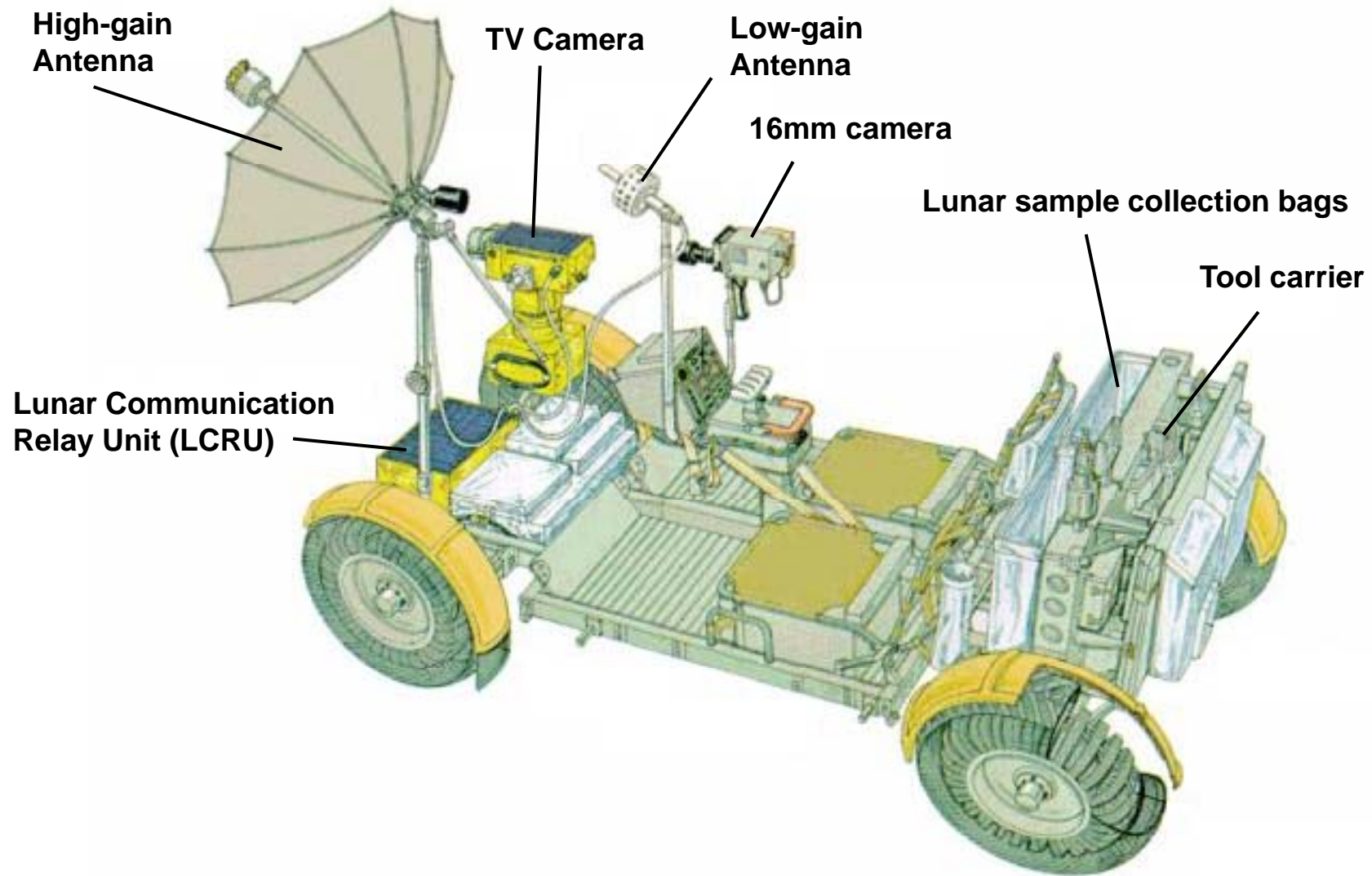
Layout, Stowage Overview



Quadrant I – Lunar Rover Deploy



Lunar Roving Vehicle (LRV)



Quadrant II – Scientific Equipment Bay



- ❑ Slide boom and Pulleys used for deploy
- ❑ Barbell arrangement for carrying experiments

EASEP – Early Apollo Scientific Experiments Package (Apollo 11)

ALSEP – Apollo Lunar Surface Experiments Package (Apollo 12-17)

Quadrant III – Tools

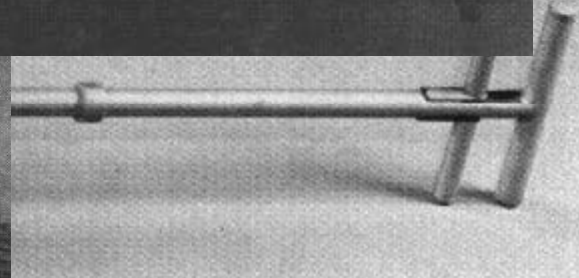
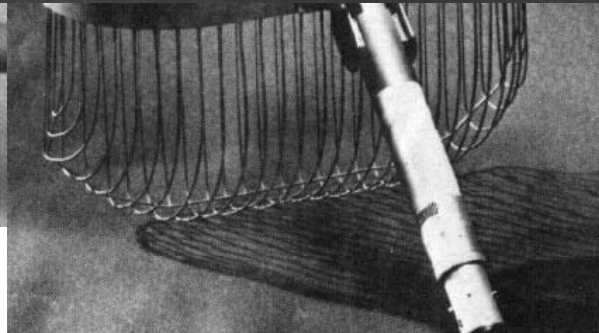
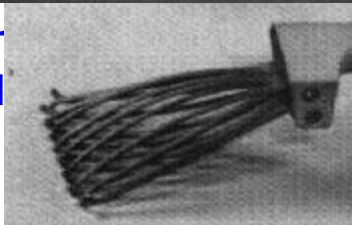
Sampling Scoop

Gnomon /
Color Patch

Trenching tool



Extensometer
Hand



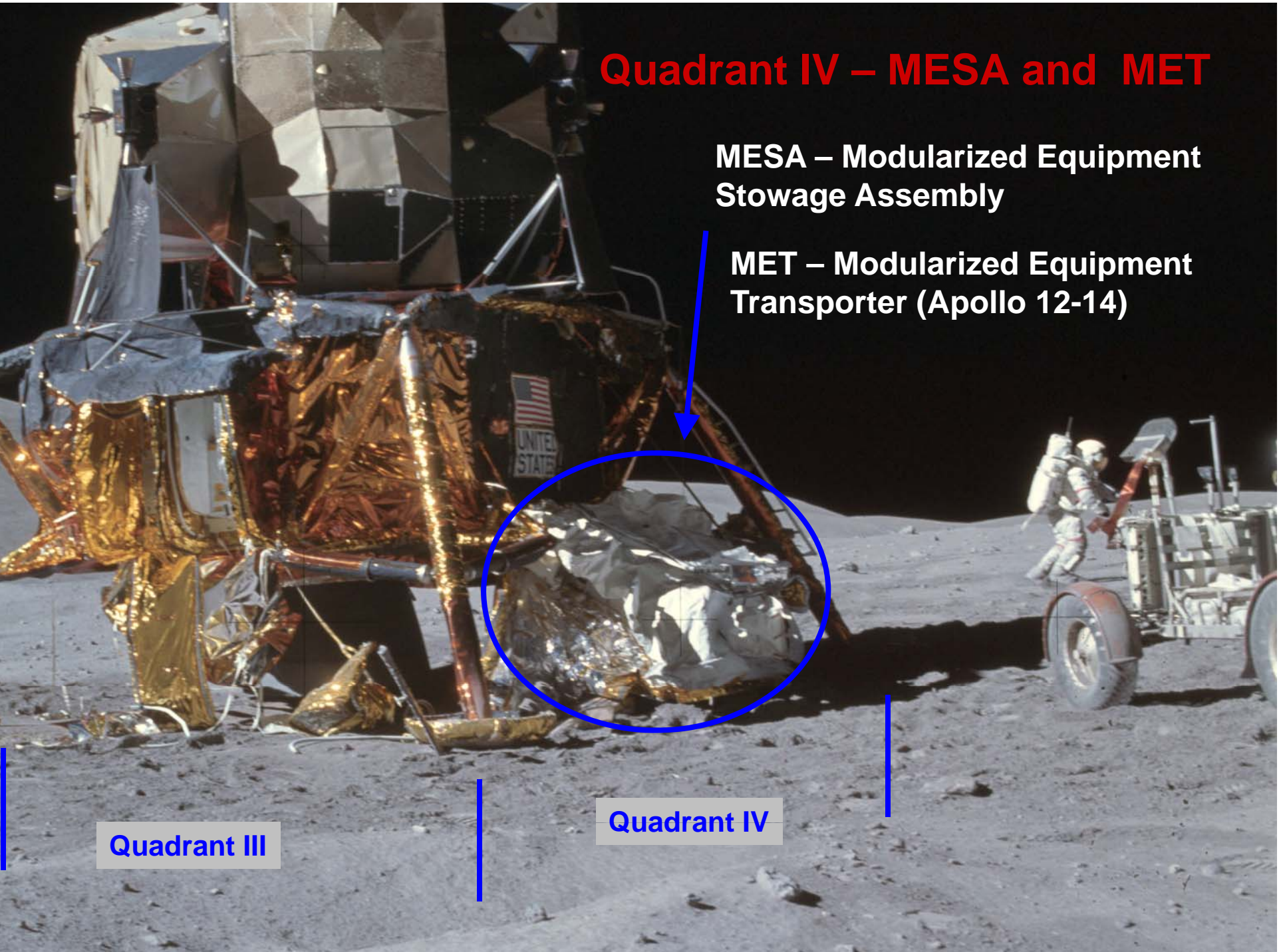
Longs

Rake

Quadrant IV – MESA and MET

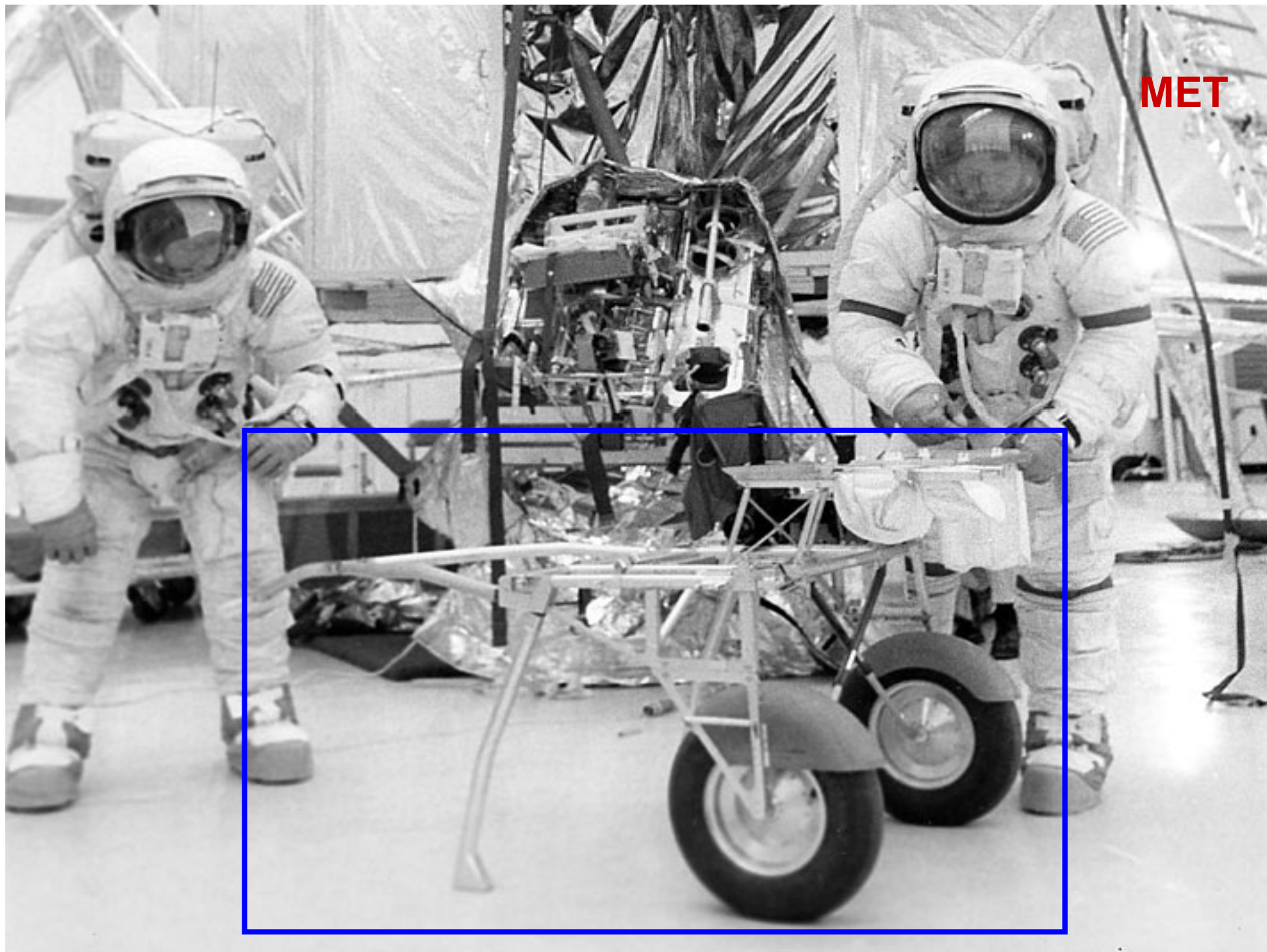
MESA – Modularized Equipment Stowage Assembly

MET – Modularized Equipment Transporter (Apollo 12-14)



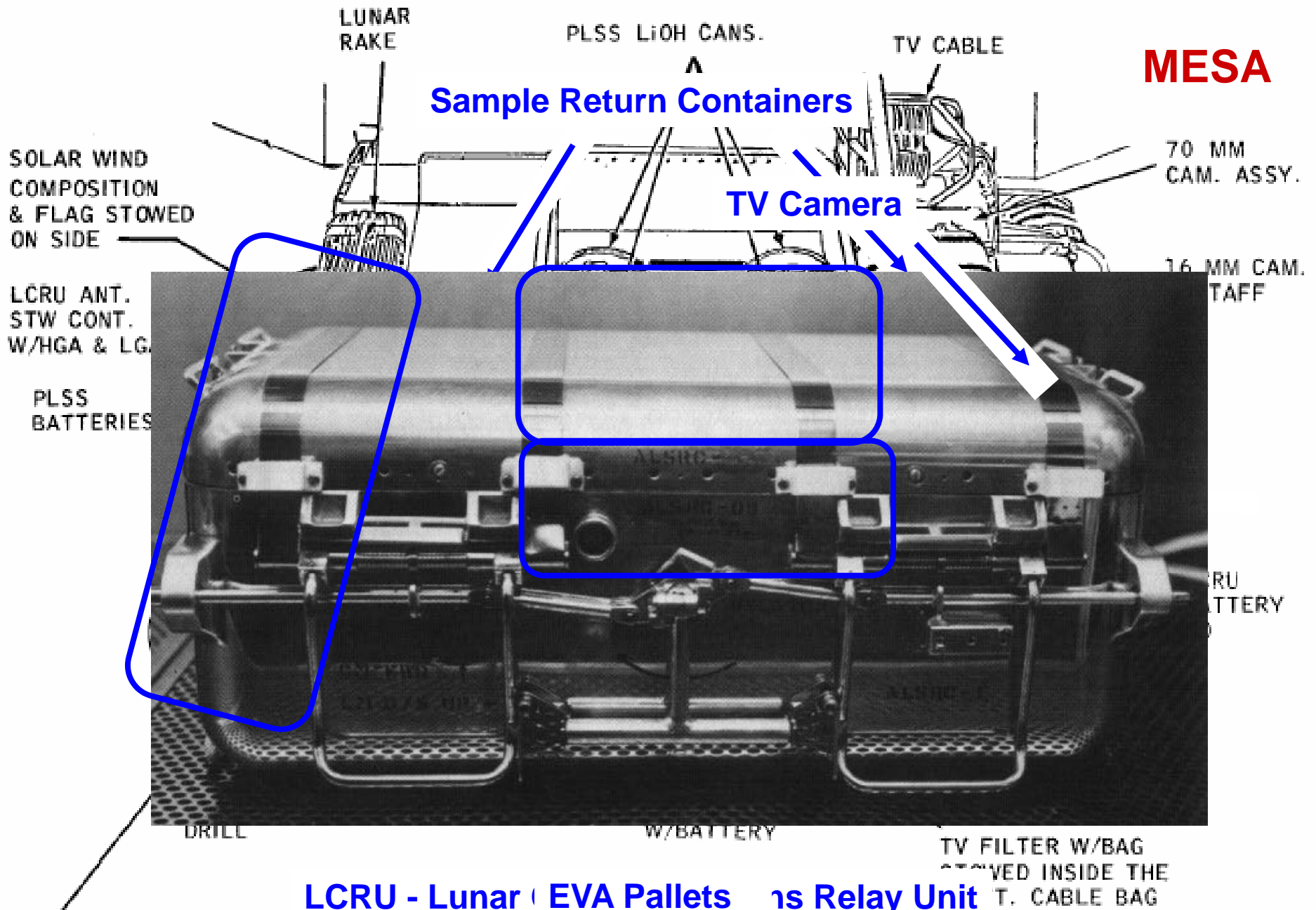
Quadrant III

Quadrant IV



MET

MESA



SAMPLE CONTAINMENT BAG (6 EA.)
SOLAR WIND COMPOSITION BAG (ON BOTTOM)

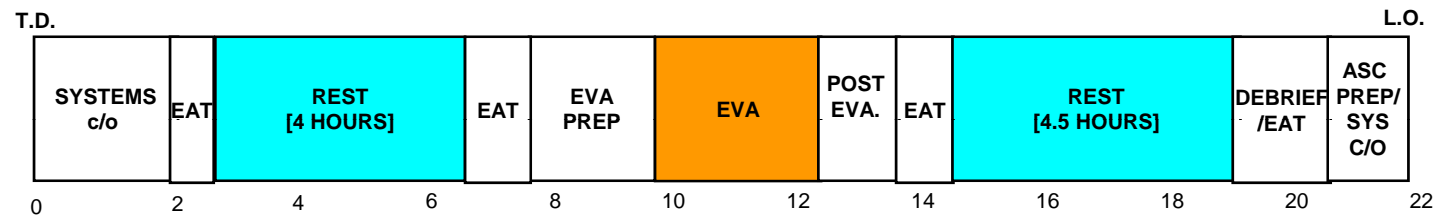
Timelines

- ❑ G Mission Apollo 11
 - 20 hours on surface
 - 1 EVA

- ❑ H Mission Apollo 12-14
 - 30 hours on surface
 - 2 EVA

- ❑ J Mission Apollo 15-17
 - 70 hours on surface
 - 3 EVA

Apollo 11 Timeline – G Mission



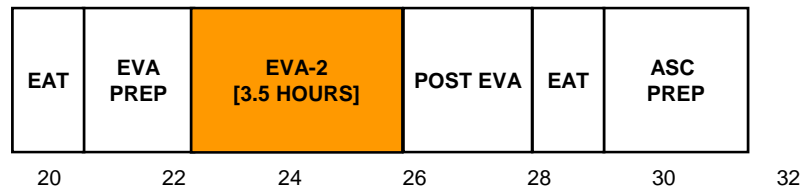
- Total surface time 21:36
- Total EVA time 2:40

Apollo 12 through 14 Timeline – H Mission

T.D.



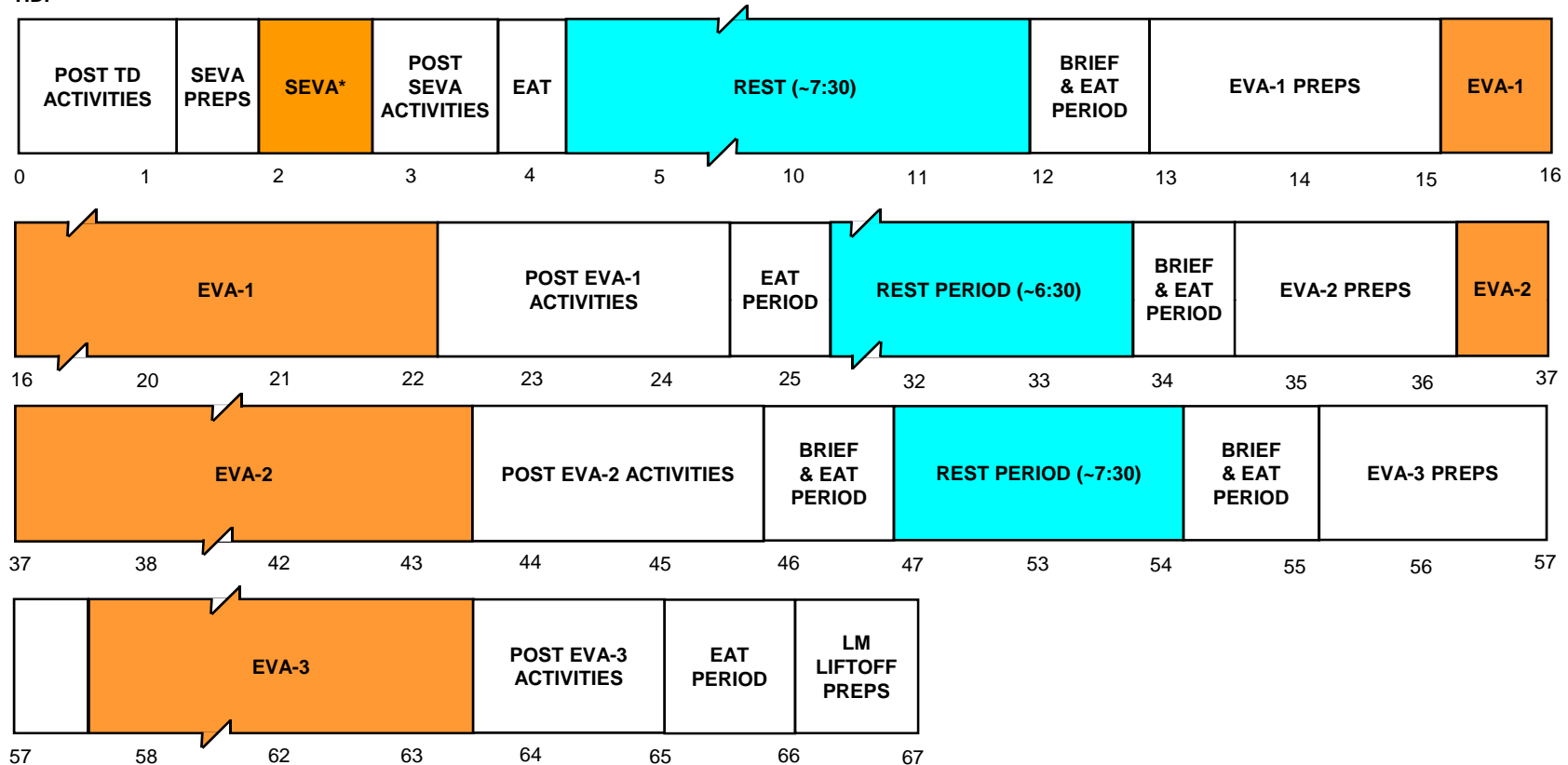
L.O.



- Total surface time 31:31
- Total EVA time 7:40 (actual)

Apollo 15 Timeline – J Mission

T.D.



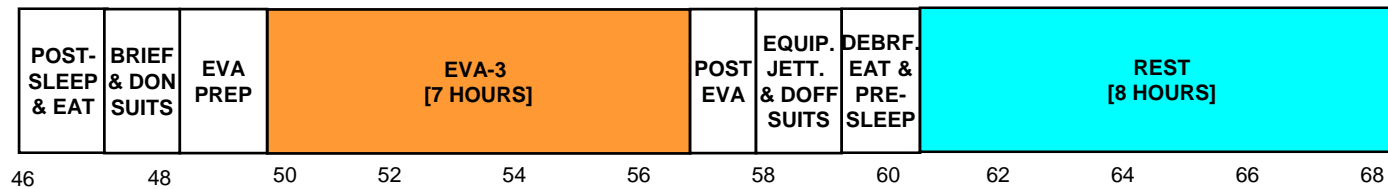
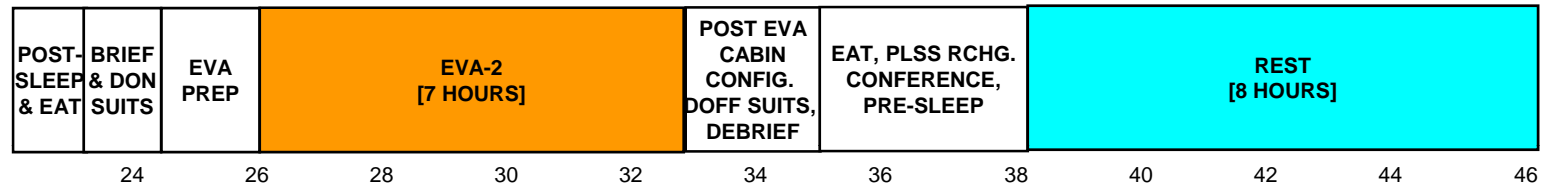
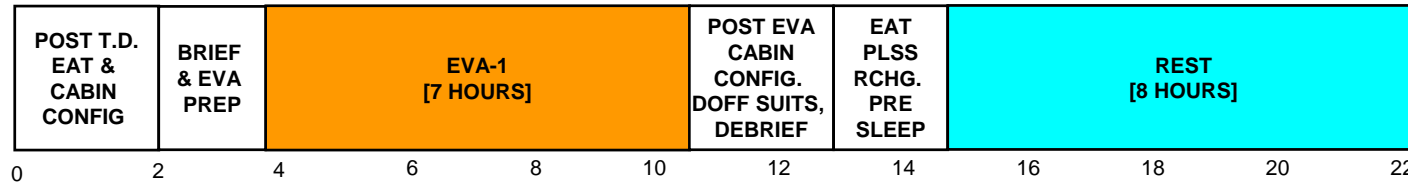
L.O.

* SEVA is Standup EVA

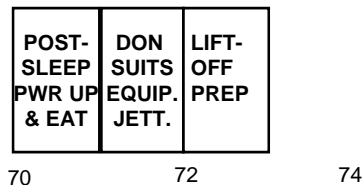
- Total surface time 67:00
- Total EVA time 19:03

Apollo 16 Timeline – J Mission

T.D.



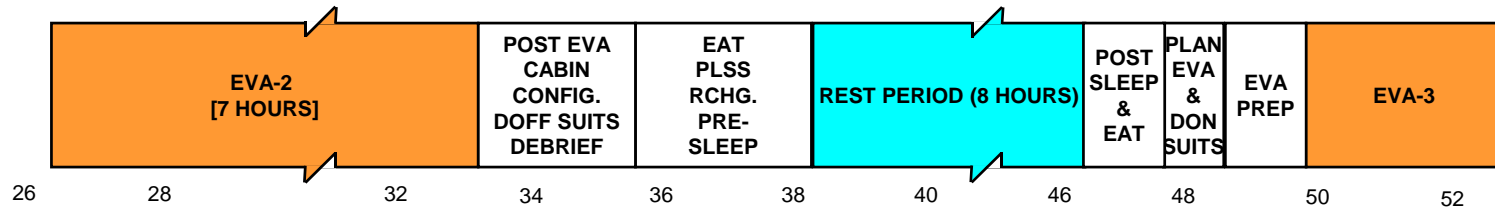
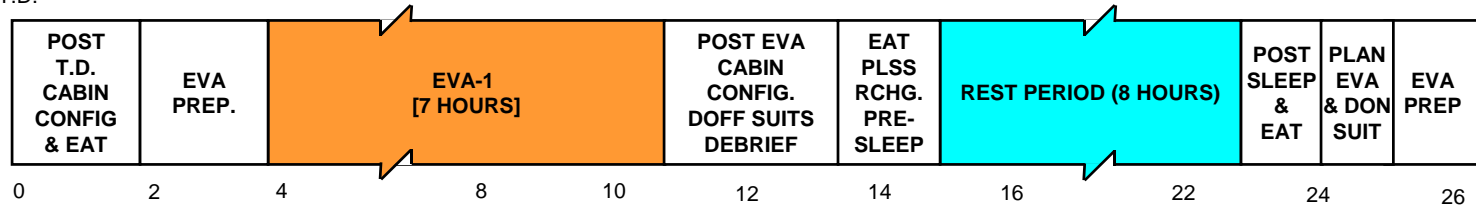
L.O.



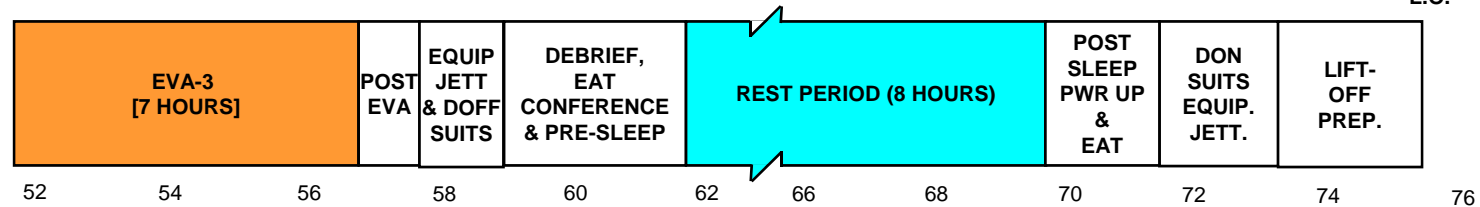
- Total surface time 72:58
- Total EVA time 20:14

Apollo 17 Timeline – J Mission

T.D.

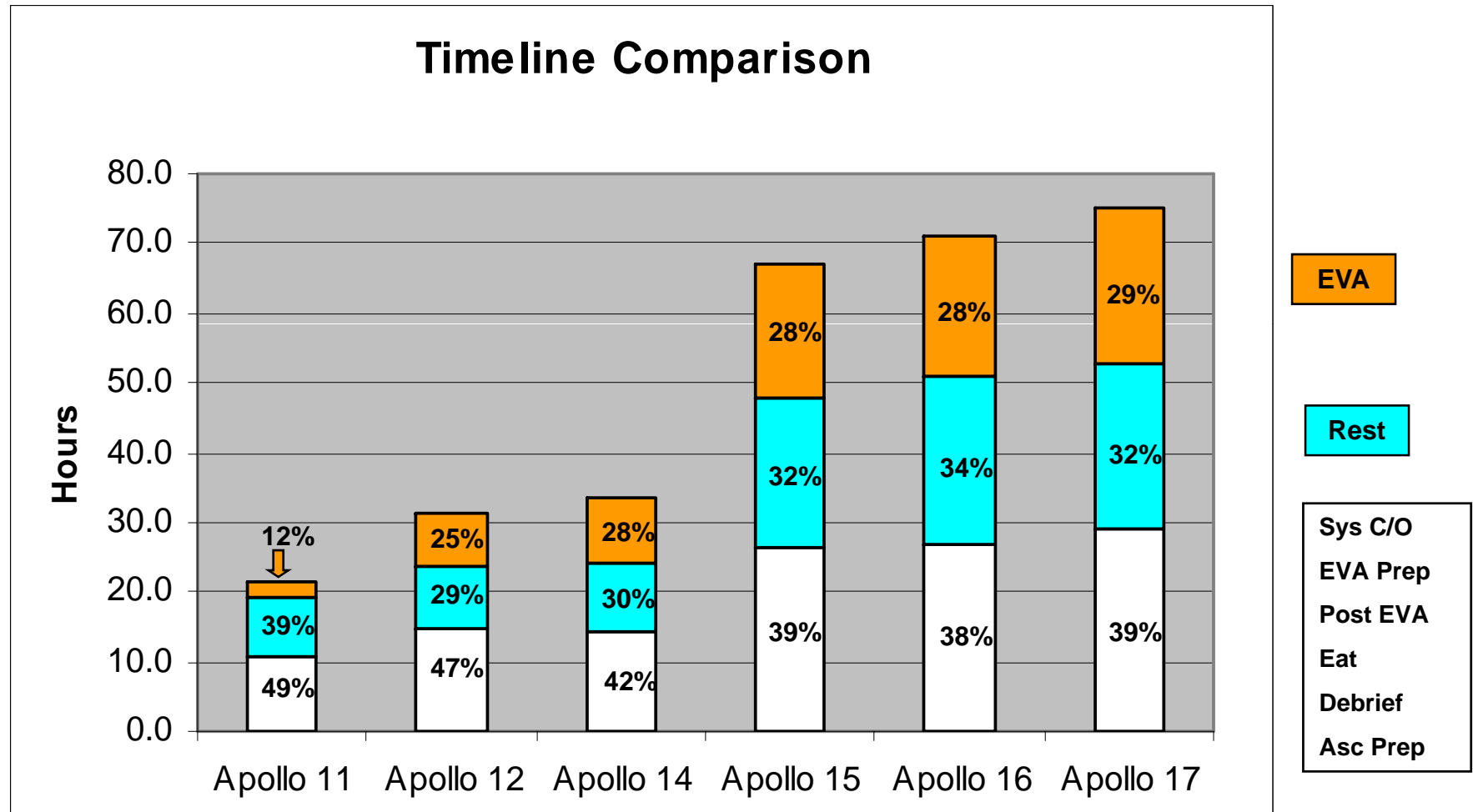


L.O.



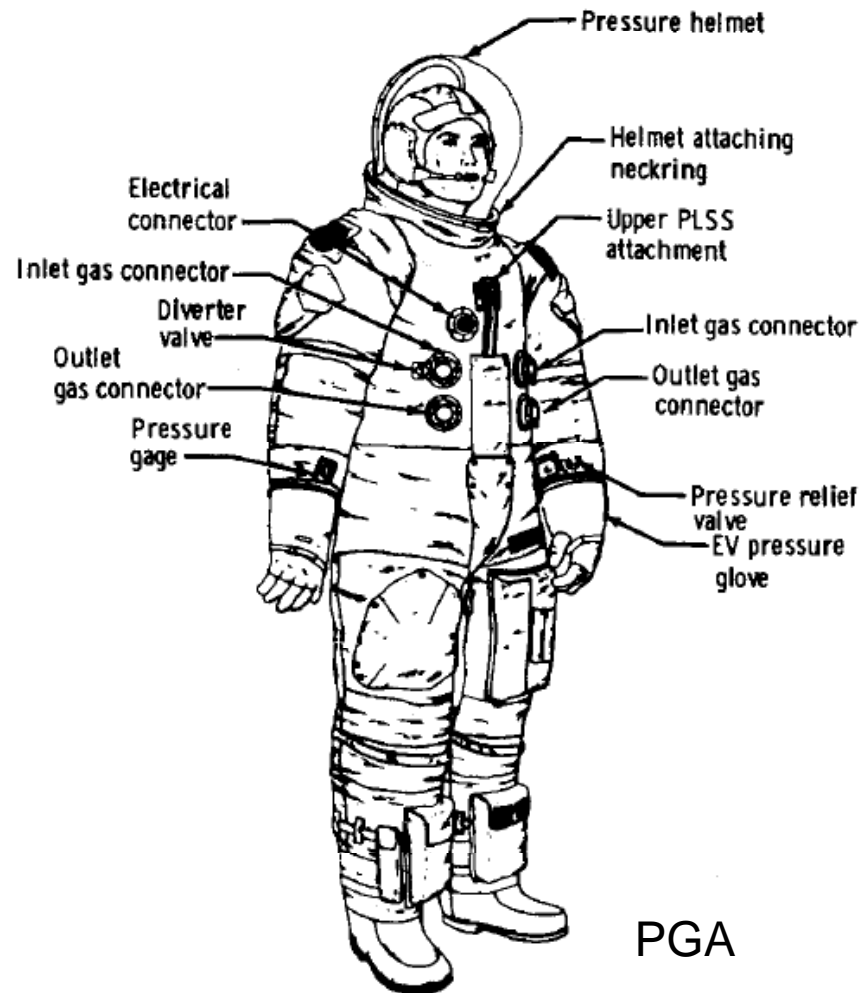
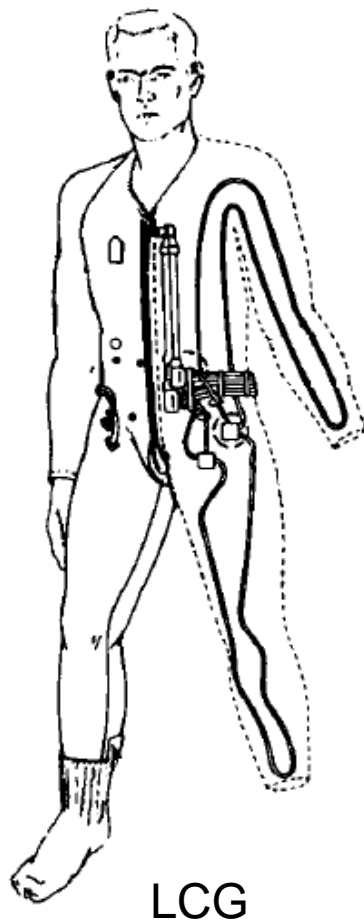
- Total surface time 75:00
- Total EVA time 22:04

Duration on Surface



❑ Don Suits

- LCG (Liquid Cooling Garment), PGA (Pressure Garment Assembly)



EVA Prep

- ❑ Don Suits

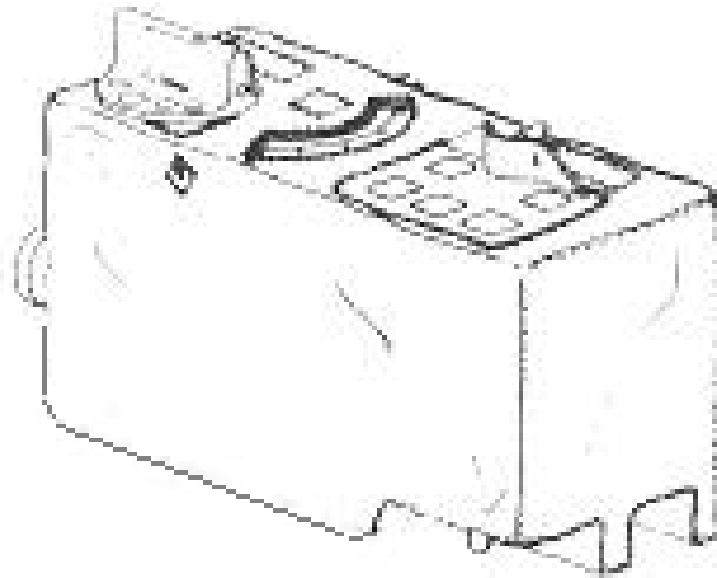
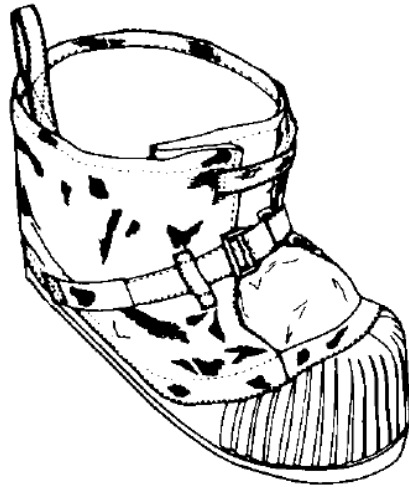
- LCG (Liquid Cooling Garment), PGA (Pressure Garment Assembly)

- ❑ Cabin Prep

- Stow the stuff you don't need

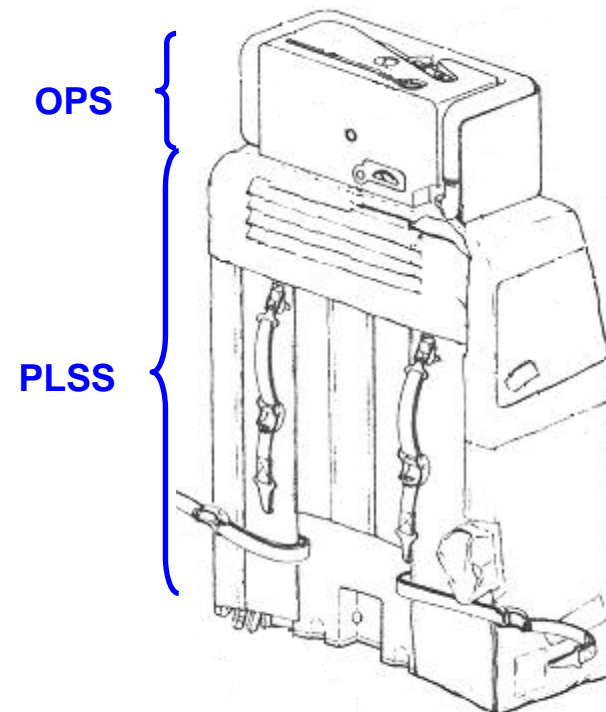
EVA Prep

- ❑ Don Suits
 - LCG (Liquid Cooling Garment), PGA (Pressure Garment Assembly)
- ❑ Cabin Prep
 - Stow the stuff you don't need
- ❑ Equipment Prep
 - Unstow boots and OPS (Oxygen Purge System), Checkout OPS, Don Boots



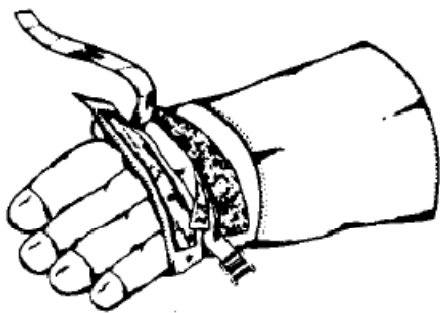
EVA Prep

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- ❑ Cabin Prep
 - Stow the stuff you don't need
- ❑ Equipment Prep
 - Unstow boots and OPS (Oxygen Purge System), Checkout OPS, Don Boots
- ❑ PLSS (Primary Life Support System, pronounced 'pliss') donning
- ❑ PLSS Comm Check

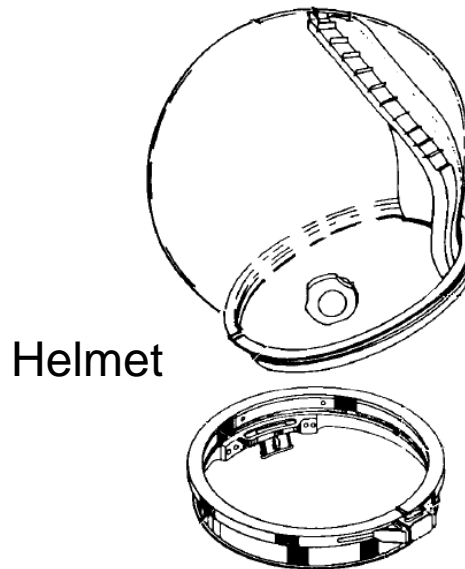


EVA Prep

- ❑ Don Suits
 - LCG (Liquid Cooling Garment), PGA (Pressure Garment Assembly)
- ❑ Cabin Prep
 - Stow the stuff you don't need
- ❑ Equipment Prep
 - Unstow boots and OPS (Oxygen Purge System), Checkout OPS, Don Boots
- ❑ PLSS (Primary Life Support System, pronounced 'pliss') donning
- ❑ PLSS Comm Check
- ❑ OPS connect, don Helmet and Gloves

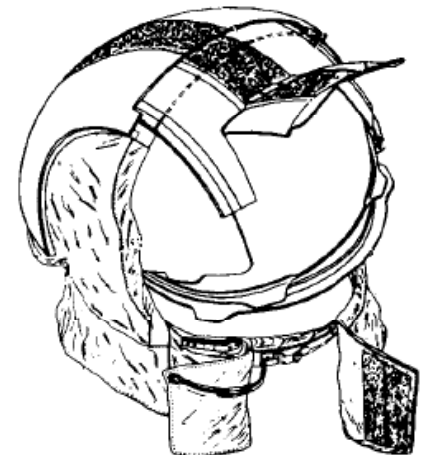


Glove



Helmet

Visor Assembly



EVA Prep

- ❑ Don Suits
 - LCG (Liquid Cooling Garment), PGA (Pressure Garment Assembly)
- ❑ Cabin Prep
 - Stow the stuff you don't need
- ❑ Equipment Prep
 - Unstow boots and OPS (Oxygen Purge System), Checkout OPS, Don Boots
- ❑ PLSS (Primary Life Support System, pronounced 'pliss') donning
- ❑ PLSS Comm Check
- ❑ OPS connect, don Helmet and Gloves
- ❑ Pressure integrity check
- ❑ Cabin Depress
- ❑ Total time: approx. 2.5 hours

PLSS and OPS

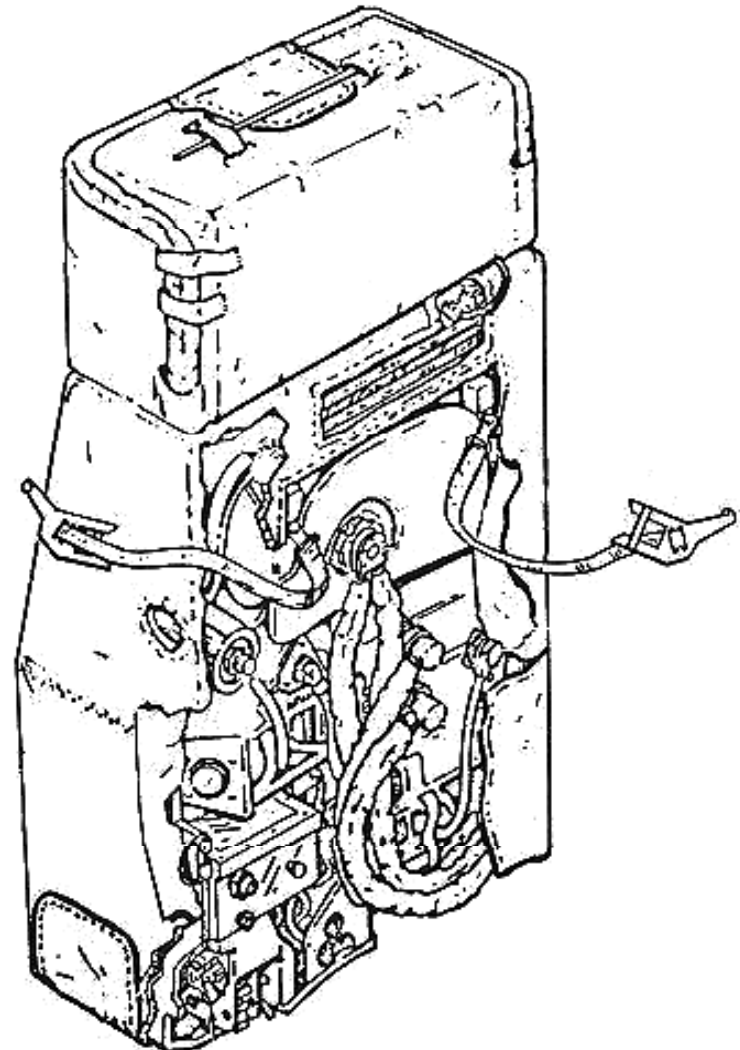


OPS

PLSS

PLSS

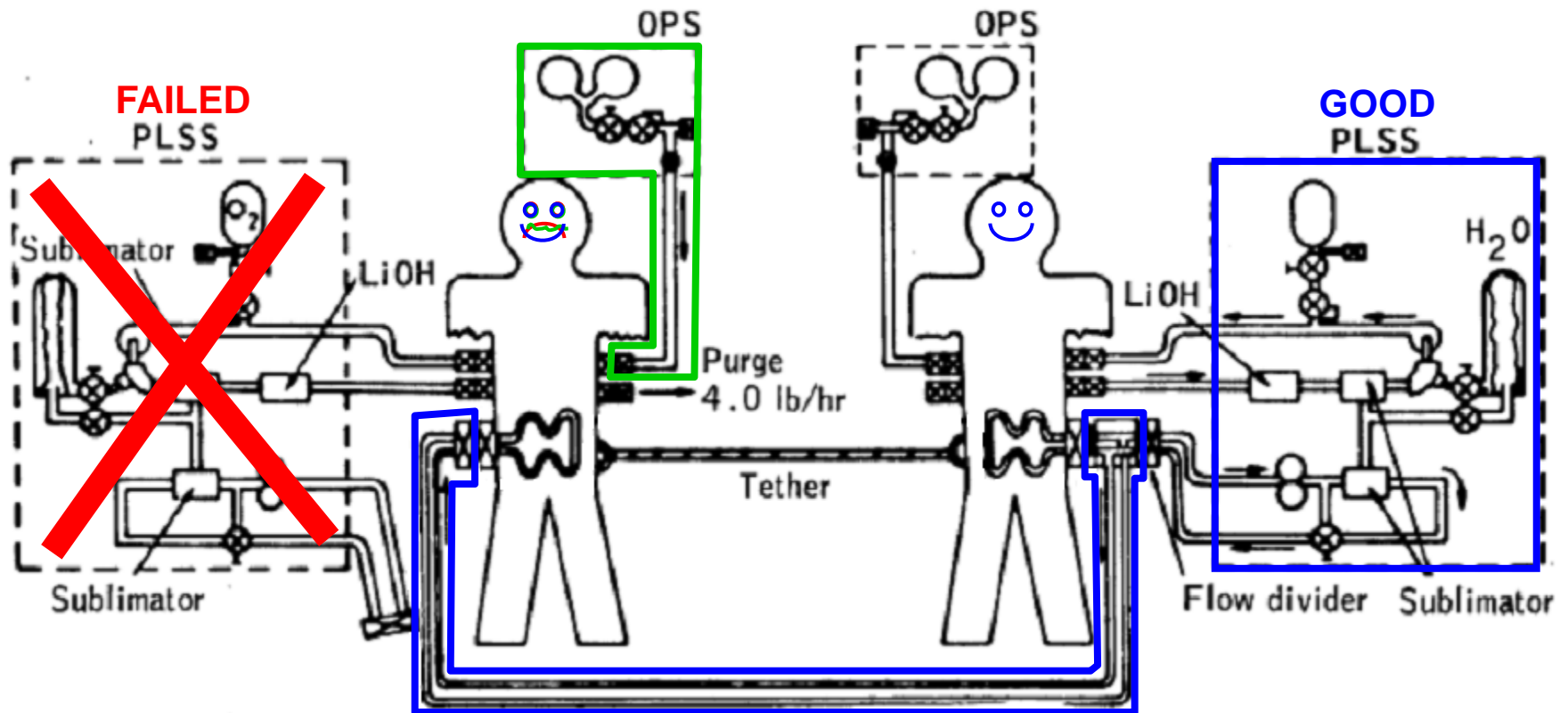
OPS



- Oxygen and cooling for 7 hours
- Comm and telemetry
- 75 minutes of contingency Oxygen

BSLSS – Buddy Secondary Life Support System

- BSLSS allows cooling circuit of one functioning PLSS to be shared

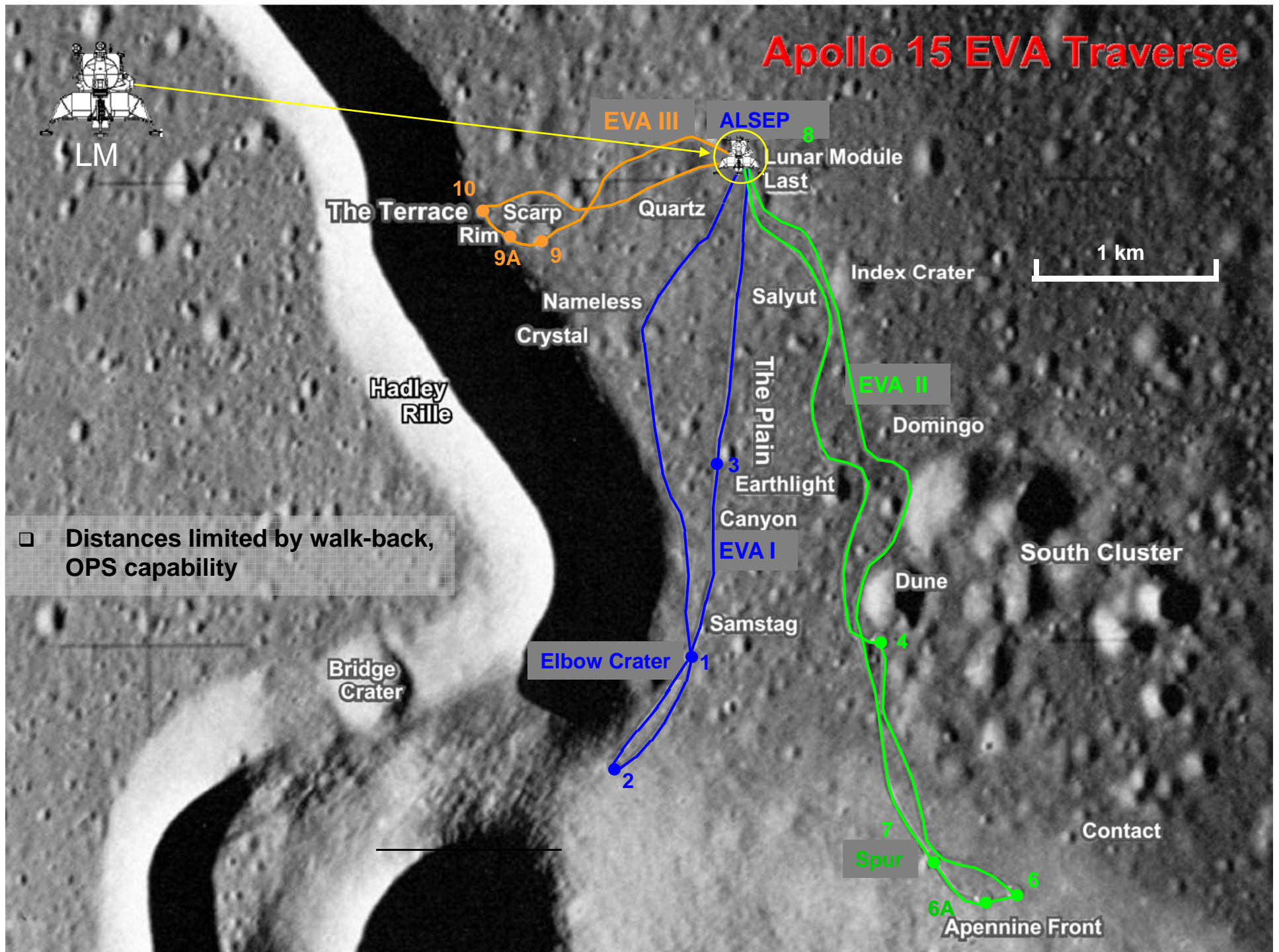


Cooling through BSLSS

EVA Objectives - Typical EVA 1

- CDR Egress, deploy MESA and Camera
- CDR Descend, collect contingency sample, adjust MESA height
- LMP (Lunar Module Pilot) Egress, descend
- LRV Setup
- Camera setup
- Load equipment from MESA to pallet, pallet to Lunar Rover
- CDR Stow contingency sample in LM,
- Travel to several stations for sample collection
- Return to LM, collect ALSEP (Apollo Lunar Surface Experiments Package) pallets
- Deploy ALSEP
- Return to LM
- Deploy Flag and Solar Wind Composition experiment
- Dust off
- Ingress

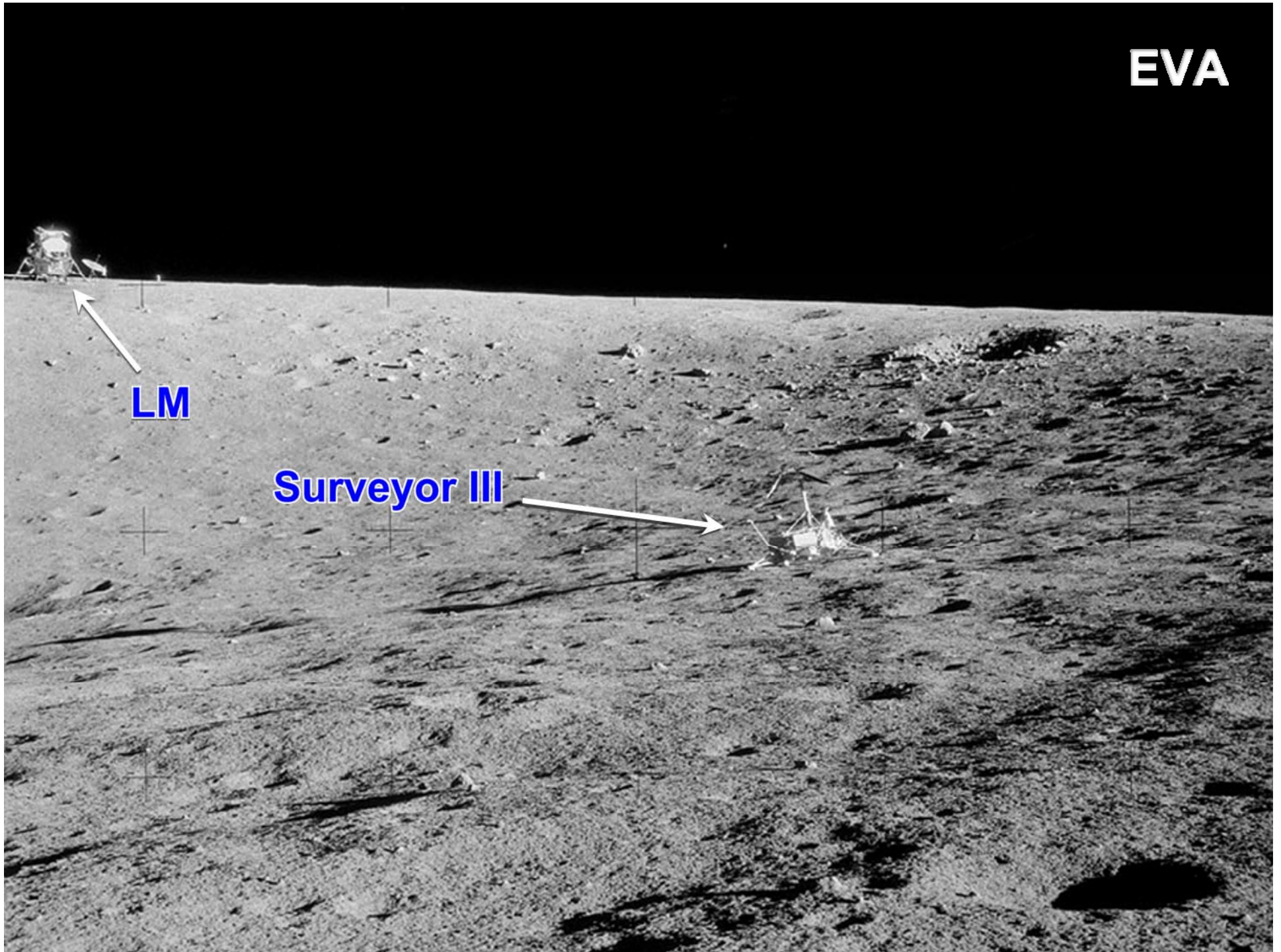
Apollo 15 EVA Traverse



EVA

LM

Surveyor III

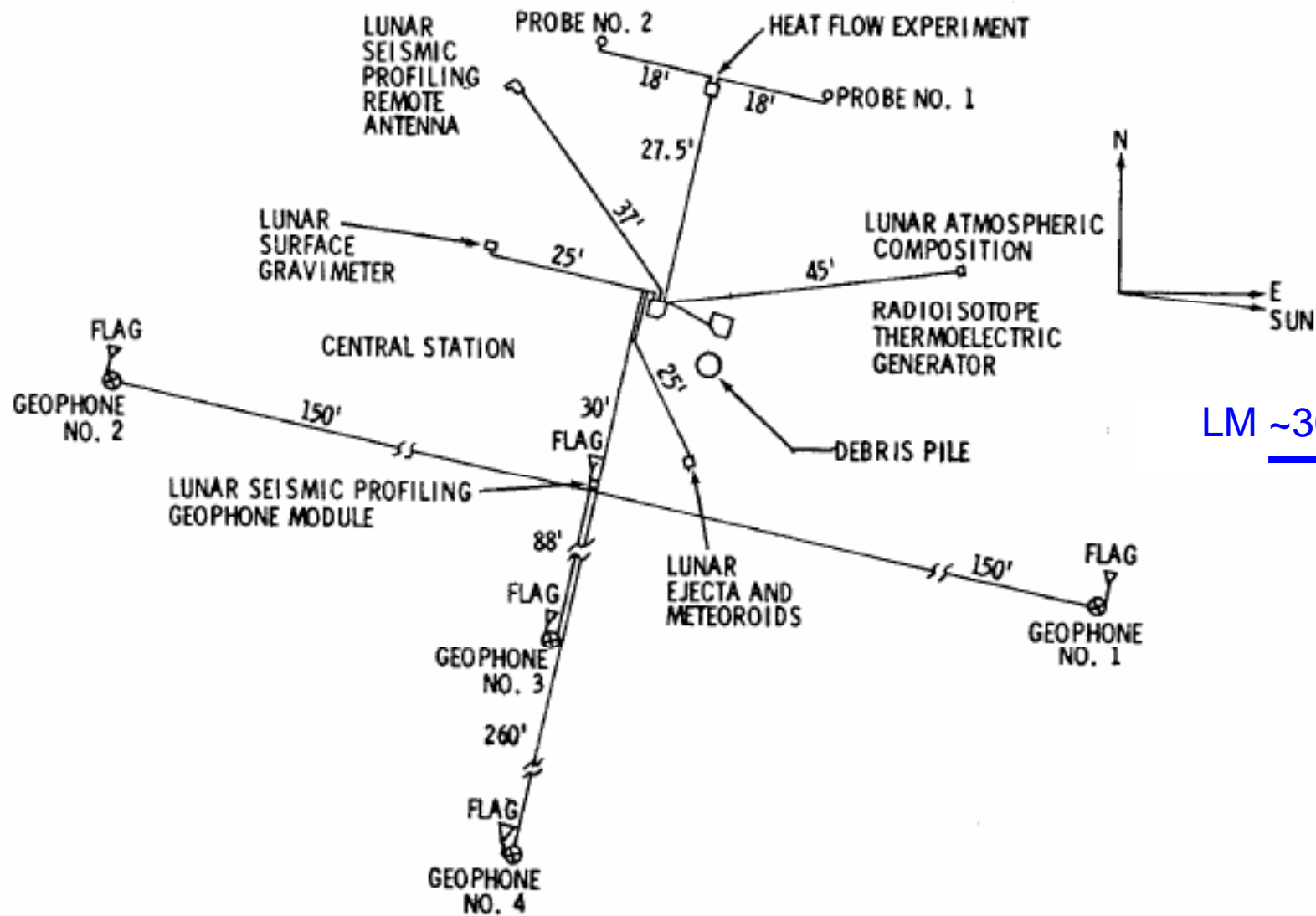


Science Objectives

APOLLO LUNAR SURFACE SCIENCE MISSION ASSIGNMENTS

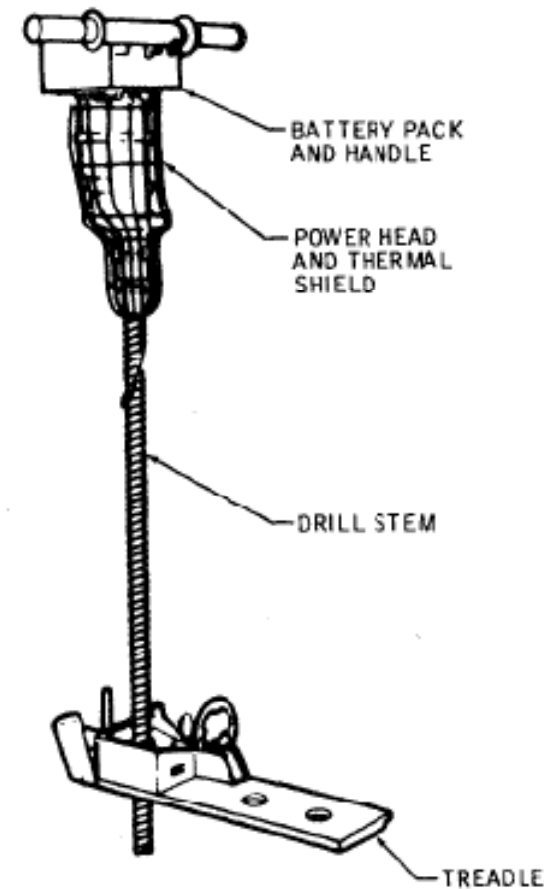
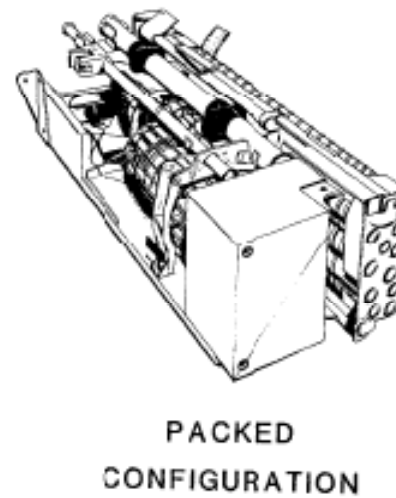
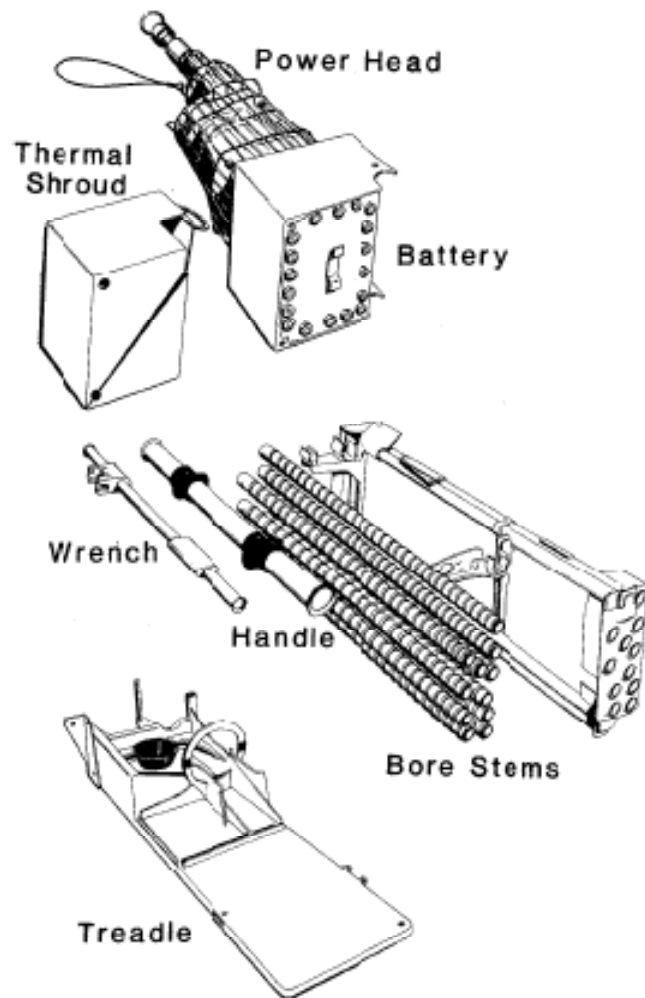
		<u>EXPERIMENT</u>	<u>11</u>	<u>12</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>
EASEP/ ALSEP	{	S-031 PASSIVE SEISMIC	X	X	X	X	X	
		S-033 ACTIVE SEISMIC			X		X	
		S-034 LUNAR SURFACE MAGNETOMETER		X		X	X	
		S-035 SOLAR WIND SPECTROMETER		X		X		
		S-036 SUPRATHERMAL ION DETECTOR		X	X	X		
		S-037 HEAT FLOW				X	X	X
		S-038 CHARGED PARTICLE LUNAR ENVIRONMENT			X			
		S-058 COLD CATHODE IONIZATION		X	X	X		
		M-515 LUNAR DUST DETECTOR		X	X	X		
		S-207 LUNAR SURFACE GRAVIMETER						X
		S-202 LUNAR EJECTA AND METEORITES						X
		S-203 LUNAR SEISMIC PROFILING						X
		S-205 LUNAR ATMOSPHERIC COMPOSITION						X
		S-201 FAR UV CAMERA/SPECTROSCOPE					X	
Stowed and performed separately	{	S-059 LUNAR GEOLOGY INVESTIGATION	X	X	X	X	X	X
		S-078 LASER RANGING RETRO-REFLECTOR	X		X	X		
		S-080 SOLAR WIND COMPOSITION	X	X	X	X	X	
		S-184 LUNAR SURFACE CLOSE-UP CAMERA	X	X	X			
		S-152 COSMIC RAY DETECTOR					X	X
		S-198 LUNAR PORTABLE MAGNETOMETER			X		X	
		S-199 LUNAR TRAVERSE GRAVIMETER						X
		S-200 SOIL MECHANICS			X	X	X	X
		S-204 SURFACE ELECTRICAL PROPERTIES						X
		S-229 LUNAR NEUTRON PROBE						X

ALSEP Deploy



LM ~300ft (100m)

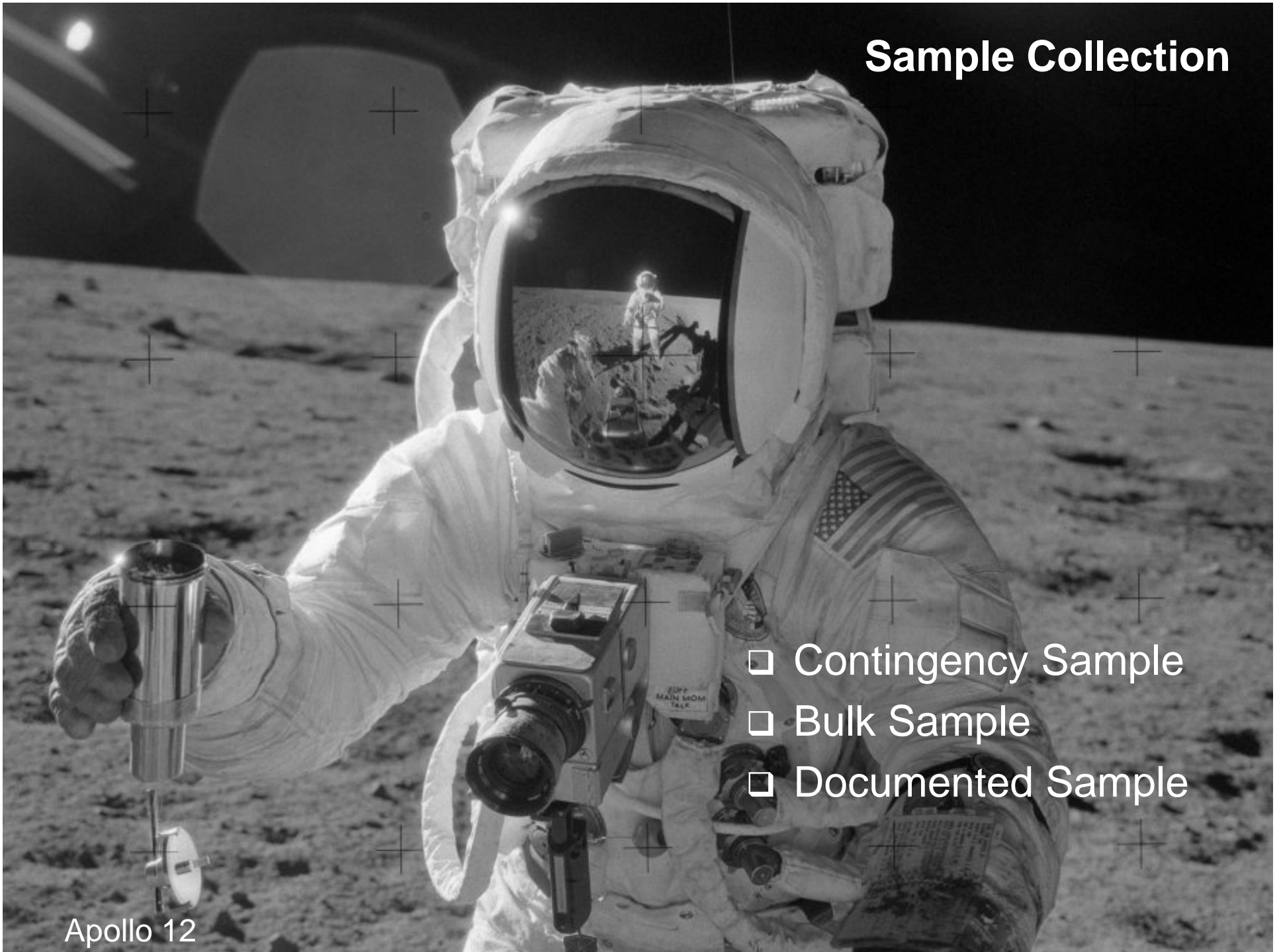
The Drill



Sample Collection

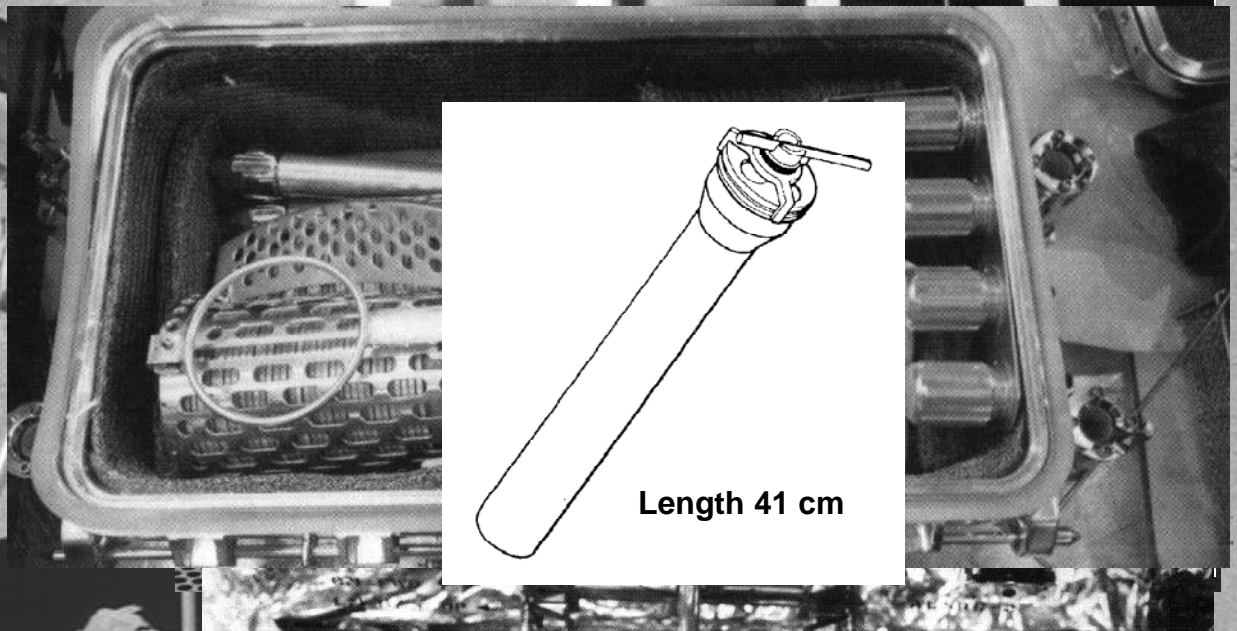
- ☐ Contingency Sample
- ☐ Bulk Sample
- ☐ Documented Sample

Apollo 12



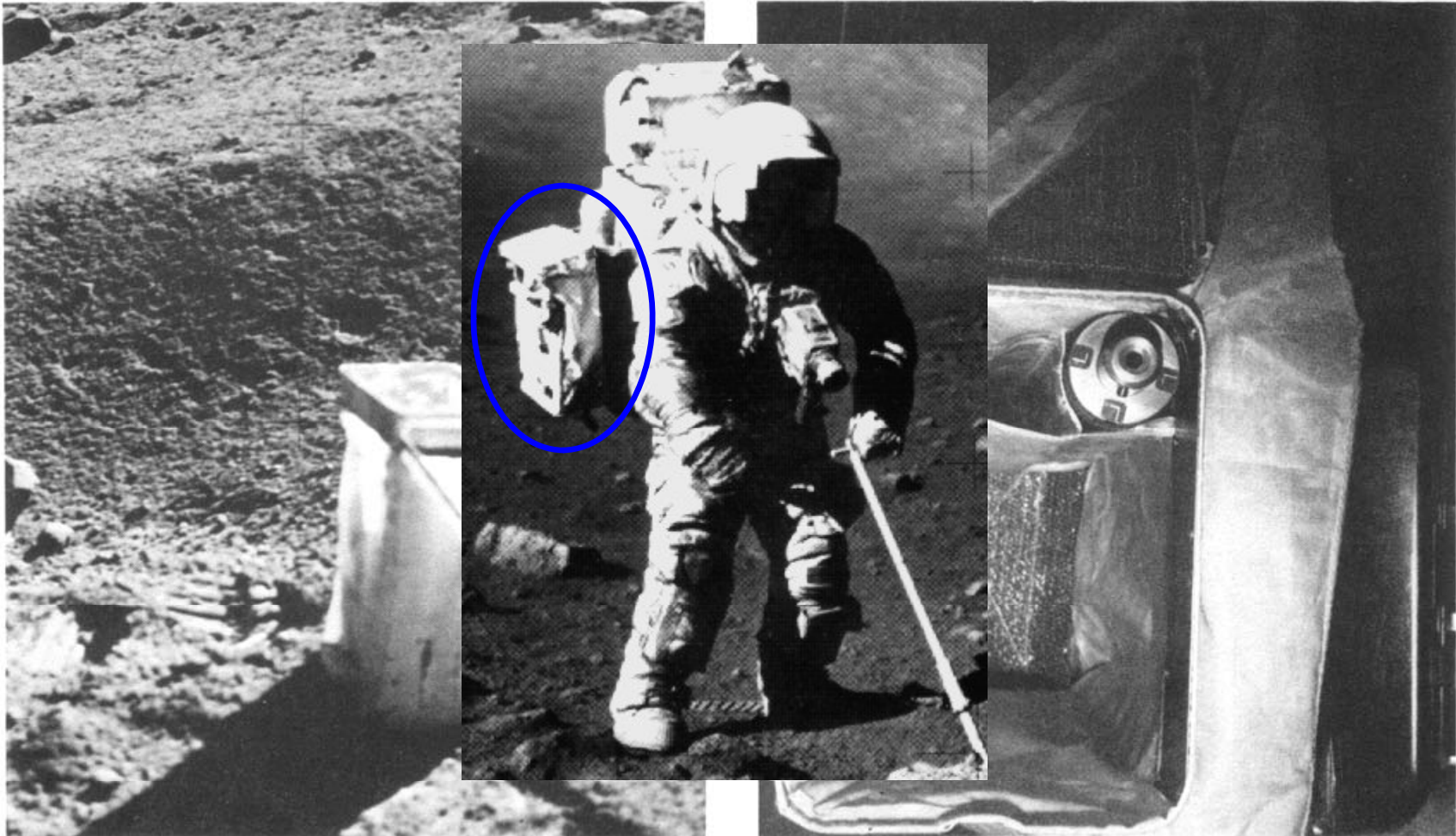
Sample Collection

■ 1800/1800 Field Deployable Sample Container



Apollo 16


Sample Collection Bag



Post EVA 1,2

- ☐ **Clean EMUs (dust off)**
- ☐ **Equipment Transfer, Ingress**
- ☐ **Hatch Close, Cabin Repress**
- ☐ **Doff gloves and helmet**
- ☐ **Connect to LM ECS (Environmental Control System)**
- ☐ **PLSS initial O2 recharge**
- ☐ **Doff PLSS and OPS**
- ☐ **Change PLSS LiOH and Batteries**
- ☐ **Stow PLSS and OPS**
- ☐ **Post EVA Cabin Config**
- ☐ **Doff Suits**
- ☐ **Weigh and stow lunar samples**

Post EVA 3

- ❑ Clean EMUs (dust off)
- ❑ Equipment Transfer, Ingress
- ❑ Hatch Close, Cabin Repress
- ❑ Doff gloves **only** (helmet stays on)
- ❑ Connect to LM ECS (Environmental Control System)
- ❑ Doff and stow PLSS and OPS
- ❑ Prep for Equipment Jettison 
- ❑ Cabin Depress
- ❑ Equipment Jettison
- ❑ Cabin Repress
- ❑ Doff gloves and helmet
- ❑ Cabin clean up
- ❑ Doff Suits
- ❑ Stow lunar samples

- Weigh lunar samples
- Wrap and tie lunar boots, armrests, RCUs, Yo-yo's
- Position PLSS's for Jettison
- Don Gloves
- Suit pressure integrity check

Lessons Learned – non EVA

❑ Training versus mission execution

- Timeline - Mission execution timed activities took longer than simulation
 - Not clean cockpit of simulator
 - More care and thought applied to each step
 - Crews reported needing an additional hour for EVA Prep over the 2.5 hours timed.
- Fidelity of training units
 - Slightly different hardware and slightly different configurations slowed the crew down and increased risk of errors

❑ Sleeping

- Sleeping difficulties due to excitement, temperature, light, noise, pressure points

❑ Eating

- Have enough food on board
- Food bar and drink pouch in EMU greatly improves endurance

Lessons Learned - EVA

❑ Walking

➤ Slopes

- Walking up or down is okay
- Moving across a slope is hard
- Standing or working on a slope is hard
- Getting in or out of the LRV on a slope is hard

➤ Wires – TV wires and others strung across the ground

- Almost invisible due to dust
- Significant tripping and entanglement hazard
- Either bury them or don't have them

Lessons Learned - EVA

- ❑ Mobility – limited ability to bend over or get anything off of the ground
- ❑ Strength and Endurance
 - No mention of fatigue in the legs
 - Some mention of fatigue in arms and shoulders
 - Barbell arrangements, shoulder straps, or other provisions was recommended
 - Grip strength, soreness of hands were significant
- ❑ Falling and getting up
 - They do fall
 - They can get up

Lessons Learned - EVA

□ Driving

- Know how to drive in snow,
 - Don't turn hard at speed
 - Don't brake and turn at the same time
- Make the seat belts adjustable

□ Visual Cues

- Objects may be farther than they appear
- Difficult to distinguish features when looking up-sun or down-sun
- Many features not recognized until crew was right on top of them
- Cannot see well from sun into shadow
 - Position vehicle with work area (like the MESA) in sun light

Lessons Learned - EVA

❑ 1/6 g adaptation

- Crew were able to rapidly adapt
- Anticipate differences in hardware performance
 - Notable instance was suit compressibility
 - Inside the LM, they took up more space
 - During EVA they sat higher in LRV, seatbelt issue

❑ Dust

- It gets everywhere
- It is an irritant to skin, eyes, and lungs
- It causes rapid failure of mechanisms
- Every effort at mitigation pays off
 - Don't get dirty
 - Dust off
 - Bag the EMU pants and boots
- Cabin clean up capability
 - Crew had whisks and wipes
 - Did not have vacuum
 - Insufficient air filtration

Summary

- ❑ Summarize Lunar Module Basics emphasizing module layout and storage.
- ❑ Identify the primary activities occurring during each of the lunar surface timelines.
- ❑ List the EVA Prep tasks
- ❑ Identify the EVA Objectives
- ❑ Identify the activities associated with Post EVA
- ❑ Describe the lessons learned during both EVA and Non EVA activities

□ Charlie Duke, Apollo 16



References

- ❑ Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers, JSC-23454
- ❑ Technical Debriefs from Apollo 11 through Apollo 17
- ❑ Press Kits from Apollo 11 through Apollo17
- ❑ Apollo 14 LM Timeline Book
- ❑ Apollo 16 Flight Plan
- ❑ Apollo Lunar Surface Journal
<http://www.hq.nasa.gov/alsj/>